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Spinning Preparation Machine and Cavity Resonator

The invention relates to a spinning preparation machine with a drafting device for drafting at least one sliver [fiber band, slubbing], in particular a carding, drafting or combing machine, with at least one microwave sensor at the inlet and/or at the outlet of the drafting device for measuring the sliver thickness of the at least one sliver, which microwave sensor comprises at least one cavity resonator through which the at least one sliver is to be guided during the measurements. The invention also comprises such a cavity resonator.

In the spinning industry at first an evened-out fiber structure is produced from, e.g., cotton in several process steps and finally a twisted yarn is produced as end product. The spinning preparation machines such as carding, drafting and combing machines arranged upstream from the manufacture of yarn have the particular task of leveling out fluctuations of sliver mass of one or several slivers. To this end sliver sensors are arranged, e.g., on drafting frames that measure the sliver thickness, also called sliver mass, and their fluctuations and transmit this information to a regulating unit that appropriately regulates at least one of the drafting members of the drafting device. Even in non-regulated drafting frames information about the fluctuations of sliver thicknesses is desired in many instances. An appropriate sensor at the output of a drafting device emits, e.g., a

corresponding cut-out signal for the machine and/or a warning signal if a threshold value of the sliver thickness is exceeded or dropped below.

The known measuring methods for determining fluctuations of sliver thickness are primarily based on mechanical scans. However, the dynamics of these mechanical sensors are no longer sufficient in the case of delivery speeds at the output of the drafting device of in particular more than 1000 m/min. In addition, the necessary strong mechanical compression in front of a mechanical sensor makes itself noticeable in a negative manner on the drafting capacity.

WO 00/12974 teaches a microwave resonator for the continuous detection of fluctuations of sliver thicknesses of moved textile strands at the inlet of the drafting device. Alternatively or additionally, a microwave sensor is arranged at the outlet of the drafting device that can be used in particular for monitoring the quality of the evened-out fiber material.

The device according to WO 00/12974 comprises a temperature sensor for measuring in order to compensate temperature influences by means of a processor. However, the cited design has the disadvantage that this temperature compensation for taking into account influences of temperature on the measured results is not an optimal solution since it is cost-intensive on the one hand and on the other hand is based on necessarily empirical calculating algorithms.

The present invention has the problem of improving the precision of measurements of sliver thicknesses relative to the conditions prevailing in spinning mills.

This problem is solved in the spinning preparation machine of the initially cited type by means for preventing temperature-conditioned deformations of the resonator walls of the microwave sensor during the measurements. The problem is likewise solved by a cavity resonator with resonator walls that are manufactured at least in sections from a material with a low coefficient of thermal expansion.

The advantages of the invention reside in particular in the fact that temperature variations that have an influence on the measuring precision when microwaves are used can be eliminated to a great extent. Expensive calculating compensation solutions can possibly be completely eliminated.

During the production start the temperatures in and on the machine are relatively low but rise with the time. In particular the development of heat due to the machine motors and other moved components as well as the sliver friction on the input and output of the cavity resonator cause a rise in temperature that results in deformations of the cavity resonator walls. Such changes of the resonator geometry cause a shifting of the resonator frequency (given an unchanged cross section of the sliver) and therewith a falsification of the measured values and/or result in inaccuracies of measurement. The measuring accuracy can be significantly raised by the means in accordance with the invention for preventing these temperature-

conditioned deformations of the resonator walls. Thus, it is in particular immaterial whether the machine has just started or has been in operation for some time. If, on the other hand, a single calculating compensation regarding temperature influences were to be performed, at first the temperature would have to be measured and the appropriate point in the correction curve found that represents the correction value for a certain temperature.

In the cavity resonator in accordance with the invention that is used in an advantageous embodiment of the machine the resonator walls are manufactured at least in sections from a material with a low coefficient of thermal expansion. Such a selection creates the advantage that temperature variations and therewith expansions and shrinkings of the resonator walls can occur only to a very slight extent. A preferred material in this connection is steel with a low thermal expansion, which steel has a thermal expansion at customary operating temperatures of approximately 1/5 and preferably approximately 1/10 of the thermal expansion of steel customarily used in textile machines. Such a steel is, e.g., an Ni36 steel, that is, a steel with a nickel component of approximately 35-37 % as well as lesser amounts of other metals as well as carbon or a steel comparable to it. Ni36 steel has an almost negligible thermal expansion, that is, the coefficient of thermal expansion at 20°C is approximately zero for such a steel. Such a steel is known, e.g., under the name of Invar® steel. Other comparable steels have other trade names. Furthermore, Ni36 steels are distinguished in

addition to an almost negligible thermal expansion in that they are relatively elastic in comparison to ceramic material, that is, they do not have its brittleness and therewith its susceptibility.

If materials are used for the resonator walls that oppose the formation of a resonance and/or the ability to measure the resonance frequency and the damping at this frequency in the cavity of the sensor, its inner walls can be provided with a conductive layer. Such a layer can be, e.g., 5 μm thick.

It is alternatively or additionally advantageous to largely decouple the sensor from the rest of the machine in a thermal sense with thermal insulating material. Such a thermally screened island prevents waste heat from motors or other moving machine elements from reaching the sensor and causing changes of volume there and therewith a shifting of the resonance frequency of the resonator.

In the case of such a thermal decoupling, e.g., insulating foils can be arranged around rather large sections of the resonator. Alternatively or additionally, the sensor can be at least partially surrounded by a thermally screening housing. In another alternative or in an additional design the connecting elements with which the sensor is attached to a machine part are fastened with a material with low thermal conductivity so that the thermal conduction at this location is substantially interrupted.

Alternatively or additionally to the previously cited passive means for preventing temperature-conditioned deformations of the resonator walls, active temperature adjustment means are preferred. This achieves great

flexibility in the adjusting of the temperature of these walls. An undesired heating or cooling off of the resonator walls can be counteracted in this instance in that the temperature is adjusted to the desired extent. To this end it is especially preferable if the temperature adjustment means can be regulated.

In order to realize such a regulation it is advantageous to provide one or several temperature measuring elements for measuring the temperature of the inner chamber of the resonator and/or the temperature of the resonator walls. To this end a conclusion can be made about the temperature of the resonator walls and/or of the ambient, e.g., by a resistance measurement. Such a known measuring device, that is economical in addition, is, e.g., a so-called PT100, that is fastened, e.g., to an outer wall of the resonator. Alternatively, an inductive coil or some other suitable measuring method can be used.

The at least one temperature element is advantageously attached to a location that is representative for the temperature behavior of the entire resonator. Alternatively, several temperature sensors arranged at different locations can be used whose signal is preferably preprocessed. It is advantageous in this connection, e.g., to use an average value or some other evaluation for estimating a representative temperature value that is used for regulating the temperature.

An inhomogeneous temperature distribution in the resonator chamber with a undesired consequence of imprecise temperature measurements can

be largely prevented if air with a constant temperature is conducted through the resonator and/or past the resonator. Such an airflow can also be used to clean the resonator chamber, especially to eliminate fibers that became loose from the fiber structure.

The regulation of the active temperature adjustment means can take place in various ways. For example, a separate control unit is provided in one embodiment. Alternatively or additionally, an evaluation unit associated with the at least one microwave sensor can be used to regulate the temperature. However, even the central machine control can assume the regulation of the temperature adjustment means.

It is especially advantageous that the temperature adjustment means comprises a heating means and that the end temperature of the resonator walls is advantageously above the temperature produced by the influences of the machines, the ambient and friction. A heating means that can be used with advantage is, e.g., a heating foil that can be attached in particular around rather large-area sections on the outside of the resonator.

Alternatively or additionally, at least one resonator wall is directly heated in that a heating voltage is preferably applied to it.

Instead of heating the resonator walls, cooling agents can be provided that adjust the resonator walls below the temperature produced by the influences of the machines, the ambient and friction.

Alternatively or additionally, cooling agents are designed to produce a cooling airflow. Such an airflow can also be used to clean the resonator

chamber and/or bordering machine sections. The above-mentioned homogeneous temperature distribution, that is desired in a few instances, can likewise be achieved in the inner chamber of the resonator by such an airflow if this airflow is conducted at least partially through the inner chamber of the resonator.

Independently of whether the active temperature adjustment means bring about a heating or a cooling of at least one resonator wall, the corresponding electrical circuit of the heating or cooling agent can be interrupted, e.g., upon reaching the desired temperature or shortly before it. If the desired temperature is exceeded or drop below, the current is closed again in order to heat or cool. It is likewise advantageous to regulate the heating or cooling agents when the machine is engaged in order to rapidly achieve the desired temperature.

The temperature adjustment means are advantageously designed as a Peltier element in order to heat or cool at least one resonator wall. The at least one Peltier element removes, e.g., the heat from the resonator wall to be cooled when used as cooling agent and the temperature of the at least one resonator wall can be maintained distinctly below the temperature that would be achieved using conventional cooling.

It is also possible to regulate different elements of the resonator differently. E.g, the resonator side facing the inner chamber of the resonator can be cooled and the side facing away from it can be heated and the corresponding resonator sections do not necessarily have to have the same

end temperature, but rather the goal is to maintain the resonator geometry constant during the measurements.

The various means for preventing deformations of the resonator walls during the measurements can be combined in various ways.

An independent aspect of the invention provides keeping the resonator chamber clean or cleaning it by an airflow. The strength and/or the flow path of the airflow can advantageously adjusted by an airflow control means, e.g., by at least one throttle flap on an air baffle element of these means. The opening width of the at least one throttle flap can be adjusted in particular manually or electrically. In particular, an automatic actuation of the at least one throttle flap can be realized. The degree of contamination of the resonator can be taken as control value, that can be determined with at least one appropriate sensor in an advantageous exemplary embodiment. Such a sensor can be, e.g., an optical sensor whose received signals become weaker with increasing contamination and finally fall below a threshold value. Other embodiments can be based, e.g., on the measuring of contamination-dependent resistance values that are a function, e.g., of a thickness of a contaminant film or grease film on the resonator walls. A conclusion about a contamination of the inner chamber can optionally also be made from the resonance signal itself, advantageously when a boundary value of the resonator characteristics (resonator quality) is exceeded when the resonator is empty. In this case the evaluation unit of the sensor

advantageously emits an appropriate signal for controlling the at least one throttle flap of another airflow control means.

The airflow can be used as a suction flow or as a blowing flow. In addition, a continuous or an interrupted airflow can be used. The time intervals can be, e.g., periodic or made dependent on an exceeding of threshold or boundary values, e.g., on the degree of contamination or on the quality of the resonator.

The sequence of the successive suction or blowing impulses can advantageously be adjusted in their duration and/or their interval in time, e.g., on an operator desk (so-called panel) and/or from a central control device in the spinning mill. In correspondence with the above, the duration, interval, strength, flow path, etc. of the airflow can be adjusted manually and/or automatically.

In an advantageous variant the airflow is actuated during a can change since, if no so-called flying can change is being realized during continuous sliver production, no measurements are being carried out on the stationary sliver or slivers at this time .

It proved to be advantageous if the airflow is directed along the fiber material and it is especially preferred if the air is conducted on sides opposite the fiber material so that an effective removal of individual fibers and other contaminating particles is assured.

The airflows for cleaning and/or temperature adjustment can be directed differently. E.g., suction can be applied to the sensor from below.

Likewise, a vacuum can be generated by airflow in a housing surrounding the sensor and insulating it thermally.

Advantageous further developments are characterized by the features of the subclaims.

The invention is explained in detail in the following with reference made to the figures.

Figure 1 shows a drafting frame with a regulation schematically shown as a block diagram.

Figures 2a, 2b, 2c schematically show a microwave sensor with funnel in front and downstream calender rollers in a top view, lateral view and rear view.

Figure 3 schematically shows a microwave sensor in a housing.

A regulating principle for drafting frame 1 is explained by way of example in the following using figure 1. The sliver thickness of entering slivers 2, in this instance six slivers 2, is detected at the inlet of drafting frame 1 by microwave sensor 3, that works in accordance with the resonator principle (microwave generator not shown). Funnel 18 designed as a compression means for compressing slivers 2 is connected in front of the resonator principle. After passing microwave sensor 3 slivers 2 are spread out to a fleece (shows as a triangle widening out toward drafting device 1a) that runs into drafting device 1a. Drafting device 1a is formed in this

instance by an entrance roller pair, middle roller pair and a supply roller pair (only the lower roller 20, 21 and 22 of the roller pairs is shown). A draft of slivers 2 is realized by clamping the slivers or fleece 2 between the rollers of the various roller pairs, that rotate with increasing circumferential speeds, viewed in the direction of sliver travel.

The measured values of sensor 3 are converted by evaluation unit 4 into electric voltage values that represent the fluctuations of sliver thickness and are supplied to memory 5. This memory 5 is designed as a FIFO memory (first-in-first-out) and forwards the voltage with a defined delay in time to theoretical value stage 7. To this end memory 5 receives a number of impulses from impulse generator 6 that is a measure for the speed of slivers 2 running through sensor 3. The slivers are transported here from the pair of entrance rollers so that it is appropriate to couple impulse generator 6 to this roller pair. Using the impulses from impulse generator 6 the voltage values of sensor 3 are retained in memory 5 in accordance with the path traversed by slivers 2 between sensor 3 and drafting device 1a. When the slivers or fleece 2 with the sliver piece to be regulated reach the fictive draft location in the draft field of drafting device 1a, the corresponding measured value is released by memory 5 and an appropriate placing handling is performed, which will be discussed in detail in the following. The interval between the measuring location a sensor 1 and the drafting location is called the regulation start point.

Alternatively, impulse generator 6 can be coupled to another roller pair, e.g.,, to a transport roller pair directly behind sensor 3 (viewed in the direction of sliver travel). In this instance the entrance roller pair does not transport the slivers through sensor 3 but rather the transport roller pair does.

Moreover, theoretical value stage 7 receives a pilot voltage from pilot tachometer 9 that is a measure for the speed of lower roller 22 of the supply roller pair, which roller 22 is driven by main motor 8. Subsequently, a theoretical voltage is calculated in theoretical value stage 7 and forwarded to control unit 10. A theoretical-average value comparison takes place in control unit 10 and the actual values of regulating motor 11 are transmitted to actual value tachometer 12 that then forwards the corresponding actual value to control unit 10. The theoretical-actual value comparison in control unit 10 is used to impart a quite determined speed corresponding to the desired draft change to regulating motor 11. Regulating motor 11 drives planetary transmission 13 so that the speeds of lower roller 20 of the entrance roller pair and of lower roller 21 of the middle roller pair is changed in accordance with the desired evening-out of the slivers. The sliver thickness in drafting device 1a is regulated at the so-called regulating start point, that is, at the draft location by the proportional superpositioning of the speeds of main motor 8 and of regulating motor 11 taking account of the cited dead [idle] time.

Other drive concepts, e.g., individual drives can be realized in other variants (not shown).

Microwave sensor 30 is arranged at the discharge of drafting device 1a and is connected in downstream from fleece nozzle 19 designed as a compression device in the exemplary embodiment shown. The sliver or sliver fleece 2' leaving the drafting device is drawn off by calender roller pair 35 connected in downstream from sensor 30. The signals of sensor 30 are supplied to evaluation unit 31 that supplies the electrical voltage signals in accordance with the sliver thickness of drafted sliver 2' and forwards them to control unit 10. For example, long-wave periodic fluctuations of slivers 2 presented to drafting device 1a can be regulated by the signals from sensor 30. Alternatively or additionally, the signals of sensor 30 are used for quality control during which the machine is advantageously turned off if a threshold value is exceeded or dropped below.

Figure 1 schematically shows that a temperature element 40, 41 is arranged on sensors 3, 30 for measuring the temperature in the inner chamber of the resonator or on a resonator wall. Several temperature measuring elements can also be used in order to order to obtain, e.g., an average temperature value. Since it was found that the measuring accuracy of sensors 3, 30 suffers on account of temperature fluctuations due to turning the machine on and off as well as on account of the machine environment and associated heating and cooling of the resonator walls, an appropriate temperature control is desirable.

Temperature elements 40, 41 forward the measured temperature values to evaluation units 4, 31. In the exemplary embodiment shown

evaluation units 4, 31 likewise serve for temperature control in order to control correspondingly designed temperature adjustment means 14, 15. In the case of sensor 3 arranged in front of drafting device 1a evaluation unit 4 regulates heating circuit 14 that assumes the heating of at least one resonator wall of sensor 3. Alternatively, at least one heating foil can be tied into heating circuit 14 that is arranged at least sectionally around the resonator, advantageously making contact, (not shown). Care is to be taken that these heating means do not cause any disturbance of the microwave resonance signals.

Heating circuit 14 can be actuated immediately after the machine has been turned on after it has been standing still for a rather long time in order to rapidly achieve the desired heating temperature. The goal is to bring the resonator walls to a largely constant temperature that is independent from the temperature in the interior of the machine but also from the ambient temperature of the machine and, if applicable, from temperature effects produced by sliver friction on resonator elements. Then, no temperature-conditioned deformations can occur at such a constant temperature, so that the accuracy of the measured values is increased.

During normal operation temperature measuring element 40 determines the current temperature, whereupon evaluation unit 4 regulates heating circuit 14 if a given threshold value is dropped below. If a given temperature registered by measuring element 40 is exceeded, evaluation unit

40 furnishes a corresponding command to heating circuit 14 for interrupting the heating process.

A corresponding design with an analogous heating method is provided at the discharge of drafting device 1a for sensor 30. Evaluation unit 31 likewise assumes the control of heating circuit 15, that is designed to adjust the temperature of at least one resonator wall of resonator 30.

The control of heating circuits 14, 15 can also be realized by control unit 10 in an embodiment that is not shown. Even specific [individual] control units can be provided in another alternative.

Instead of a heating of the resonator walls and/or of the resonator chamber a cooling can be realized. It is important that the resonator walls are adjusted to a substantially constant temperature in order to suppress volumetric fluctuations of the resonator chamber as well as distortions of the resonance field.

In alternative or additional designs the resonator walls are manufactured at least partially from a material with a low thermal expansion, e.g., Ni36 steel (e.g., Invar® steel). Other possibilities that can be used alternatively or additionally include the thermal insulation of the sensor with the aid of fastening elements that suppress the conduction of heat that are attached to the machine and/or include thermal insulation housings and the like.

Figures 2a (top view), 2b (side view) and 2c (rear view) show microwave sensor 300, shown without a microwave generator, with funnel

118 in front and calender roller pair 135 that draws the at least one sliver 2 through funnel 118 and sensor 300. In figures 2a, 2b the at least one sliver 2 is indicated solely by a dotted arrow; in figure 2c sliver 2 is shown in cross section as a composite of many individual fibers. Furthermore, funnel 118 and calender rollers 135 are not shown in figure 2c.

Instead of funnel 118 other sliver guide elements can also be used, e.g., horizontally and/or vertically arranged deflection rods that can, e.g., also have concave guide surfaces in order to allow the at least one sliver 2 to run into sensor 300 in a centered manner. Furthermore, calender rollers 135 can be arranged rotated through 90° or any other angle.

Sensor 300 comprises resonator 300a with two semicylinders 301, 305 separated by slot 310. Outer walls 302, 306 of semicylinders 301, 305 are manufactured from metal and inner walls 303, 307 oriented toward sliver 2 are manufactured from ceramic material. The resonance develops in the inner resonator chamber between walls 302, 306.

An airflow is conducted through slot 310 in the direction of sliver travel on both sides of sliver 2. This airflow is shown in figures 2a, 2b in dotted lines and in figure 2c as a circle with crossed lines sketched in it (direction of airflow is directed away from the observer). The air flow or airflows 50 can assume several functions. On the one hand they assure a largely homogeneous distribution of temperature in slot 310 and on the other hand they prevent a depositing of, in particular, fibers on inner walls 303, 307 of semicylinders 301, 305 as well as on the discharge of resonator 300a

and at the transition to calender rollers 135. Such deposits of contaminants would detune resonator 300a and result in inaccurate measurements.

Furthermore, airflow 50 can be used for a purposeful adjustment of temperature, in particular of resonator walls 302, 306. In particular, it is possible to use cooling air in order to cool off resonator walls 302, 306 to the most constant temperature possible, that is lower in comparison to that of normal operation.

Figure 3 shows another embodiment of a microwave sensor 3000 in which, in contrast to the embodiment of figure 2, a housing 45 is additionally provided around cavity resonator 3000a. Housing 45, whose front wall facing the observer is shown removed, is thermally insulated in order to keep heat coming from the machine room and the environment from resonator 3000a. In addition, two slots 312, 314 are provided between the outer walls of resonator 3000a and the inner walls of the housing through which slots airflow 51 is conducted. Even these airflows 51 can be used to clean slots 312, 314 and/or to adjust the temperature of the resonator walls.

In figure 3 the airflows guided to sensor 3000 branch off into two partial flows, on the one hand into airflow 51 already described and on the other hand into airflow 50 running through slot 310. As an alternative, no airflow 50 through slot 311 or an airflow 50 provided specifically for slot 310 is provided.

Airflow 50, 51 in figures 2, 3 can be blowing or suction flows, which latter produce a vacuum in slots 310, 312, 314.